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J.F. Campbell Esq [illegible]
8. From the Author :

ON THE RELATIVE AGE

OF SOME VALLEYS IN THE

NORTH AND SOUTH OF ENGLAND,

AND OF THE VARIOUS AND

POST-GLACIAL DEPOSITS OCCURRING IN THEM.

BY CHARLES E. DE RANCE, ESQ., F.G.S.,

H.M. Geological Survey.

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In the early days of Geological Surveying it was the custom to disregard the various deposits of clay, sand, loam, and gravel, which were believed to have been scattered by "diluvial forces" over the surface of what were called the regular formations.

As the application of Geology to Agriculture, Engineering, and Medical Science increased, an exact knowledge of the various Drift, or superficial deposits, became of importance, for in many districts they entirely cover up the older rocks, in some instances to a depth of 400 feet, and exercise a more important influence on the pursuits, health, and condition of the people living on their surface, than do those older formations, which are alone shown, on ordinary geological maps.

A detailed examination of these Drift deposits, in various parts of the British Isles, proved that so far from their having a common diluvial origin, their structure is exceeding complex, due to a number of forces, acting through long periods of time, during which great climatal changes took place. Some of these beds being due to the melting of stone-laden icebergs in a Glacial sea, others to the ground moraine of an ice-sheet wrapping over large portions of Britain, whilst other deposits, though formed after the period of cold had passed away, were the old alluvial sediments brought down by existing rivers, before they had cut down their valleys to their present depth.

Whilst yet other deposits, though later in time than the newest Tertiary period, were yet pre-Glacial, expressing a Continental period, which forms a link between the present and past, during which, through old forms of life constantly becoming extinct, and new species appearing from other areas, there was a constant series of over-lapping, the new emigrant being ever present at the death of the original inhabitant, whose ground it occupied, to whose extinction it contributed in the struggle for life, and whose place in the economy of nature it took up.

The completion of the maps of the Government Geological Survey, with the superficial deposits expressed, of two important districts, viz.:—the Thames Valley around London, and the whole of South Lancashire, enables us for the first time to compare the sequence of the two districts one with the other, with a view to seeing how far they may be correlated, and how far, by light borrowed from the one we may read the history of the other.

GLACIAL DRIFT OF LANCASHIRE.

The high watershed forming the eastern margin of Lancashire, along the Yorkshire border, is for the most part a Driftless area, but in the Coal Measures basins lying between the various spurs, thrown out westwards from this Pennine watershed, between the Mersey and the Ribble, Glacial Drift occupies the valleys and creeps up the hills to a height of 500 and even 1300 feet.

North of the Ribble, the Fells, forming the watershed, end off more abruptly, and overlook the Drift-covered plain of Lancaster, Garstang, and Preston, a continuation of the Triassic and Coal Measures Drift-covered plains to the south.

Between Warrington, Wigan, and Ormskirk this lowland plain is subject to undulations, sections proving the Drift to wrap round a pre-Glacial system of hills and valleys, the rock often cropping out at the top of the hills, but in the plain northward of Wigan and Ormskirk, Glacial Drift overlies a pre-Glacial rocky floor rising slightly inland, and situated far beneath the present high-water mark under the line of the existing sea-coast. So that rock sections are hardly ever seen, and inland are only met with in the beds of the streams at the bottom of the deepest valleys.

At Preston and Blackpool, the Glacial Drift exhibits what may be called its normal sequence in the north west of England, consisting of :—

Upper Boulder Clay . . .	About 80 feet
Middle Sands and Shingle . .	„ 60 „
Lower Boulder Clay . . .	„ 30 „

The Sands in West Lancashire are exceedingly current-bedded, generally in a S.S.E. direction, the shingle-beds are often of considerable thickness, very local, and contain perfectly rounded pebbles and numerous marine shells, some of the latter exceedingly perfect though excessively fragile. The pebbles are chiefly derived from local deposits, but when Lower Boulder Clay is present in the district, the fragments consist of erratics from the Lake District, often more or less scratched. When the Sands and Shingle are found high up in a Coal Measure, or Millstone Grit district, fragments rolled into pebbles of Coal Measure sandstones, coal, and Millstone Grit are common.

When sections of the bed of the Ribble, its tributaries, or other rivers taking their source further inland are observed, the Glacial deposits are found to occupy old pre-Glacial valleys, producing the phenomenon, termed *Valley within Valley*, the existing valley being excavated in the Drift, and of a much smaller sectional area, and as Mr. Tiddeman in 1867 pointed out, many of the brook valleys of North East Lancashire and West Yorkshire are merely re-excavations and enlarging " fossil water courses, following in the steps of the pre-Glacial pioneers."

In the Furness district of North Lancashire, the same general sequence of Glacial deposits obtains; Upper Boulder Clay rests on sands and gravels at Ulverston, and a Lower Boulder Clay can be seen resting on the rock, but in following any of the streams reaching the sea in this district into the deep valleys of the Lake District from which they flow, the sequence is lost, and the character of the Drift becomes more and more confused as the mountains are approached. Well preserved moraine mounds occur in numerous valleys, far above the level of glaciated rocks lower down in the valleys, and there is clear evidence of an early excessive glaciation, during which era those lakes which lie in the rock-basins probably came into existence, and of later nestling glaciers, which shrunk gradually as the period of glacial cold passed away.

Glaciers large enough to have deepened valleys into rock-basins and score their sides with striæ, must have left large moraines, almost the only evidence of which now exists in their transported fragments lying scattered over the plains of the south imbedded in the Boulder Clay. And it is in the highest degree probable, that all trace of these old moraines of the Lake District were obliterated, first by the deposition of marine deposits on them, during the submergence, and secondly by the denuding away of the material filling up the valleys by the glaciers of the second period, which, judging from their well preserved moraines, must have existed after the re-elevation of the land. The amount of moraine sediment deposited in the valleys of the Lake District was probably comparatively small, through their being filled with land ice during the submergence.

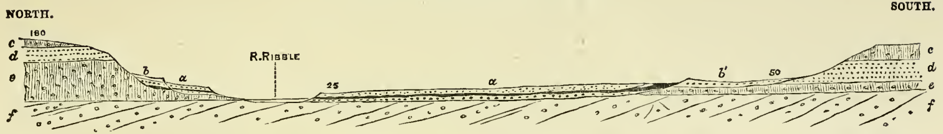
In some sections in South Lancashire, as at Brinscall, the Middle Sands do not rest on a Lower Boulder Clay, which generally resembles the Upper Boulder Clay in colour, consistence, character of included fragments, and in the presence of marine shells, but on a dark tough clay, resembling the "Till" of Scotland, and formed like it by the grinding of an ice-sheet over a local area. Near Llandudno in North Wales I noticed a bed of Till of this description, underlying the ordinary Lower Boulder Clay, Middle Sands, and Upper Boulder Clay; so that I am inclined to correlate the Till with the period of the formation of the rock-basins and the glaciated surfaces of the North of England found beneath the later marine beds known as the Lower Boulder Clay, &c.

POST-GLACIAL VALLEY DEPOSITS.

In some streams denudation is threefold: *vertical*, cutting the channels downwards, always acting from below upwards, or from the outfall towards the source; *longitudinal*, cutting away the banks on both sides when the streams flow straight, and the outer side only when it flows in a curve; and *horizontal*, when the streams or rivers, through excessive curving, in addition to wearing the edge of its channel wears it completely backward, causing the water to be thrown diagonally at the hill or bluff forming the limit of the valley, which thus receives the whole horizontal width of the stream. Gravel is constantly brought down by the rush of the stream during floods, but is only deposited in the river-bed, while the matter held in suspension is deposited on the banks

SECTION 1.

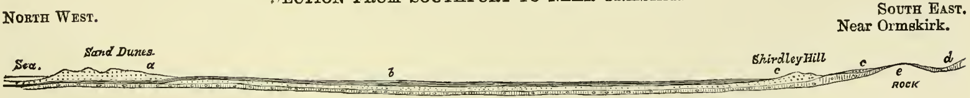
THE VALLEY OF THE RIBBLE.



a. Alluvium of the Ribble, consisting of Loam, Peat, and Gravel.
b. River Terrace, with the same sequence of deposits as *a.*
c. Upper Boulder Clay.
d. Middle Sands and Gravel.
e. Lower Boulder Clay.
f. Pebble Beds, of the New Red Sandstone.

SECTION 2

SECTION FROM SOUTHPORT TO NEAR ORMSKIRK.



a. Sand Dunes. *b.* Peat. *c.* Shirdley Hill Sand, a range of ancient Sand Hills.
d. Boulder Clay, overlaid by *Scrobicularia* Clay in the western area, which partly overlies the Shirdley Hill Sand.
e. Rock—Keuper Marls and New Red Sandstone.

when the velocity of the water is lost or diminished. When the river has cut as low as it can and the land remains stationary, the course is constantly being changed, and the gravels deposited at a previous time re-arranged; remarkable instances of this are shown by Mr Fergusson to take place near the Delta of the Ganges. The river in undermining old banks and terraces, and re-depositing their materials in newer banks and alluvial flats, mixes included fragments of various ages in one deposit.

Valley of the Ribble.—The first section (Section 1) to which I would wish to draw attention is one across the valley of the Ribble, a few miles east of the town of Preston. The river has here cut through the great Drift plain between Chorley and Lancaster down to the rock beneath, and excavated its bed, near Preston, to the lowest possible level, namely to low-water mark, the spring tides flowing two or three miles up the river beyond the town. The river has excavated for itself a gorge, with an average width of a mile and a half, bounded by steep walls or bluffs, here and there worn into cliffs, exhibiting fine sections of the Glacial Drift, of an elevation varying from 80 to 200 feet.

The whole of the excavation of this gorge, 20 miles long and 150 feet deep, must have taken place since the era of the Upper Boulder Clay, or in post-Glacial times, and since the country had acquired its present level; for if the country had stood lower, the sea would have shaved the country across, instead of excavating a comparatively narrow valley; and if the country had stood higher, the river would have excavated its bed deeper, or below low-water mark, which is not the case, as, whenever the rock is visible, it is seen extending under the Drift as a flat surface, in every direction.

The Ribble wanders in a series of S-like curves through an alluvial plain; and wherever the bend of the S cuts the boundary-walls of the plain, there the process of river-cliff making ensues: the cliff is worn back and back, until the river, by cutting across a bend, finds a new channel; then the talus formed at the base of the cliff, being no longer removed by the river, accumulates, until a gradual slope, covered with grass, is formed, and the cliff becomes a bluff. As the bends of the river are nearly a mile apart, and they alone exercise the primary horizontal denuding power, it will be seen that, for the formation of the bluffs, once cliffs, the bends of the river must have been successively upon every point of the bluffs forming the bounds of the plain. And as the vertices of these bends move with extreme slowness, it follows that, when the river twice denudes the same point, it must flow at a *lower* level the second time than it did the first. This will account for the fact that terraces of Lower Boulder Clay have been left at the base of the bluffs at higher levels than the alluvial plain, the top of the terrace marking the level of the river when it last denuded that point.

The river is now depositing silt, or alluvium, during every flood produced by a freshet from the land or a high tide from the sea, except at the points where denudation of the old banks is at work. Similarly we find here and there superimposed terraces of alluvial gravel, at heights of from 20 to 100 feet above the present level, formed in the concave curves of the S's when the stream stood higher than at present, and cut the terraces in the Lower Boulder Clay before referred to.

The wasting action of the river has in many cases completely worn away all the alluvium, and turned the bluff bounding the valley into a steep cliff, with the river flowing at its base, but at the point where Section 1 is taken, the river has not completed its work, and fragments of old river terraces above the level of the present alluvial plain are still preserved.

A detailed section of these terraces, though of course subject to local variation, closely corresponds in sequence of the nature of the beds composing it with that exhibited in by far the larger number of the sections of the present alluvial plain, namely—

1. Sand, Loam, Fine Gravel.
2. Peat, Trunks of Trees and Clay.
3. Coarse Gravels.

Probably representing—

1. *Deposition* of matter denuded from alluvial plains above.
2. *Obstruction* of drainage.
3. *Denudation* of valleys above.

West Lancashire Sea-Coast.—Following the Ribble to its delta the coast line is found to be fringed with broad tracts of sand hills or dunes, rising to a height of 60 to 80 feet, and occupying a tract of country from a mile and a half to four miles in width. The sand gradually thins out on the landward or eastward margin, and is found to rest upon peat, which form extensive masses between Liverpool and the Ribble near Preston, many of which are below high-water mark, the sea being kept out by the sand dunes, and the drainage being artificially taken off by steam and wind power.

Beneath the sand dunes on the sea-coast also the peat crops out, and at its base occur the roots of a forest, imbedded in the grey clay beneath, while trunks of trees lie scattered in many directions, but generally with their heads lying to the N.E., as if they had been blown over by a gale from the S.W. The bases of the trunks left standing in the places where they grew, all appear to have been broken off at a uniform level ; and it is most probable that through the drainage being obstructed, water surrounded the trees, which gradually became rotten at the point of contact of the air and the water, and thus the way was prepared for the effects of storms and hurricanes.

Inland the same phenomena are observable, trees are found *in situ* beneath the peat, and in draining operations cart loads of trunks and snags of trees are found, some of which are in a sufficiently good state of preservation to be used for window frames and doors, especially those of oak. Alder, ash, and Scotch fir, are also common, and the various trees generally occur together, but an exception is to be found at a section north of the Ribble near Rossal School, where there is a distinct horizon of oak, over that of Scotch fir, as is the case in Denmark. A little north of this section, about two miles from Fleetwood, a large number of Roman coins were discovered in the *Scrobicularia*-clay, which overlies the peat at a depth of eight feet from the surface, and below high-water mark, so that the levels of land and sea have remained very constant since the Roman era. This is also supported by the fact of the occurrence of the remains of a Roman bath, at Dow Brook near Kirkham, close to the Roman road running between Ribchester, Preston and the sea, which "bath" and road are only about 10 feet above the present high-water mark at spring tides.

Under the peat, on the seaward side, and extending inland for some miles, is a deposit of estuarine grey clays, containing at times freshwater shells, and at other places *Scrobicularia piperata* and other marine shells ; underlying this clay, and further inland under the peat, is a deposit of marine sand, which, on the landward edge of the plain, rises into a range of ancient sand dunes. This sand I have called the Shirdley Hill Sand, from the highest of these old sand dunes. North of the Ribble, the place of this sand is taken by a bed of shingle which is well seen near Presall Hill east of Fleetwood, where it lies on the Upper Boulder Clay. When the sections in the great peat moss lying south of the Ribble, are followed into the region of the alluvium of that river, the peat is found to underlie the ordinary alluvial loam, and rests on a coarse river gravel, which occupies the horizon in the valleys of the Shirdley Hill Sand and Presall shingle-beds in the plains.

Beneath the sand dunes at Dove Marks, near Hoylake on the coast of Cheshire, the following succession of beds occurs :—

	ft.
1. *Bithynia tentaculata* Sand	2 to 4
2. Peat, sometimes with a cultivated surface	1
3. *Tellina balthica* Sand, with seams of Bluish Clay. This is apparently the seam in which Mr. Ecroyd Smith has recorded the presence of Saxon and Roman coins	2
4. Peat. The representative of the thick peat of Lancashire and Cheshire	3
5. Bluish-grey Clay, the upper portion of freshwater origin	3
,, ,, the lower of marine, and containing *Scrobicularia*	1
6. Peat, with a few stumps of trees with their roots in	1½
7. Boulder Clay. From half-tide to the lowest water-mark.	

In the lowest peat (6) no historical or natural remains have, I believe, ever been found ; but some of the flint weapons in the Liverpool Museum are believed to have come out of this seam, others from the base of the peat above. In addition to the flint weapons, Mr. Ecroyd Smith believes it to contain bones of *Bos primigenius* and *Megaceros Hibernicus*, and of Cetacea ; but these bones, I think, possibly are those that were found in the blue silt resting on a peat bed with a forest on its surface, in excavating Wallasey Pool for docks in 1858, and which have been described by Mr. T. J. Moore in the " Lancashire Historic Society's Transactions." In this case they are more probably of the age of the *Tellina balthica* sand, as the peat in Wallasey Pool no doubt belongs to the main or thick peat of the district, which, near the Birket, attains a thickness of nearly 20 feet. In this peat bones of horses, oxen, and deer have been found, as well as great numbers of Roman and Saxon coins, and in one portion arrow-heads of stone, shell, and flint. The latter substance must have been brought to the spot, either from southern counties or from eastern Yorkshire.

Great numbers of coins of all ages are constantly being picked up on the North-Cheshire beach, most of which are no doubt washed out of the main peat and the overlying *Bithynia* and *Tellina* sands. Amongst those preserved in the Liverpool Museum are some of Nero, Antoninus Pius (A.D. 138-160), Marcus Aurelius, others struck at Carthage, others struck by Canute and by various English kings from William I. to William III. Various antiquities have been described by Dr. Hume from this coast in his "Ancient Meols;" but the exact position from which they were derived is in almost every case extremely doubtful. But after carefully examining all the objects from the coast of Wirral in the Liverpool Museum, as well as the coast-section, the following correlation of historical periods with the geological formations appears to be warranted:—

Present time to Norman Conquest	Sand Dunes.
Danes and Saxons	*Bithynia tentaculata* Sand.
Saxons	Peat and Made Earth.
Saxons and Romans	*Tellina balthica* Sand.
Romans and Celts	Main Peat.
Celts	,, lower portion.
Neolithic-weapons race	Lower Blue Silt.
No trace of man	Lowest Peat.

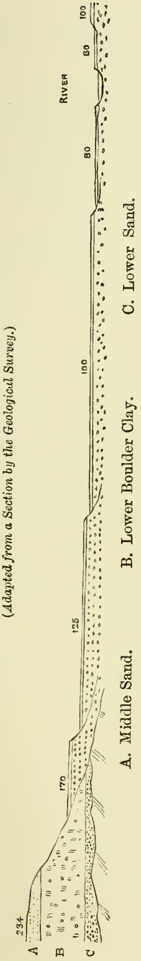
These extensive peat and forest-beds from occupying a similar position around all the low coasts and the entrance to almost all the larger rivers of England and Wales, must belong to the same episode in post-Glacial history, during which continental conditions prevailed.

Valleys of the Irwell and Upper Mersey.—So far back as 1847, Mr. Binney, F.R.S., described the occurrence of terraces of coarse gravel with beds of sand, occasionally stratified, on the sides of the three great valleys near Manchester, and he gave a section across the valley of the Irwell, from Pendleton to Kersall Moor, showing *that* valley to have been mainly excavated at that point in the Glacial Drift. The valley of the Irk, between Crumpsall and Harpurhey, is also cut through the Drift, with terraces of Drift at the bottom, on the New Red Sandstone and Coal Measures; but in the narrower part of the valley further south, the alluvial terraces disappear, but come on again where the stream falls into the Irwell. The Medlock at Bradford and

SECTION 3.

RIVER TERRACES OF THE VALLEY OF THE IRWELL.

(Adapted from a Section by the Geological Survey.)



Berwick is also cut out of Glacial Drift, down to the Coal Measures, and on the south side of the stream at Ardwick commences that great sheet of alluvial terraces which extend through Hulme, Manchester, and Salford, along the course of the Irwell. Mr. Binney, like all other geologists of that period, in this paper refers the formation of these valleys in the Glacial Drift to the action of the sea, believing the present streams to be inadequate to the work.

In 1862 Mr. Binney exhibited a map of the Drift Deposits around Manchester, showing the Valley Gravels, and described the highest terrace in the Irwell valley as occurring below Barr Hill, 86 feet above the present river; another terrace occurring at 40 feet near to Pendleton Colliery, where there is a good section of it, which with many others in the district Mr. Binney was good enough to show me in January last. I was particularly struck with the section at Clifton Junction, where about 40 feet of bedded gravel abuts against an old cliff of Glacial Sands and Gravel, which it so closely resembles that it was not until Mr. Binney had shown me a great number of sections throwing light upon it that I was convinced of the correctness of his conclusion. But the resemblance can readily be understood when it is remembered that these Valley Gravels are merely re-assorted Boulder Beds and Gravels, made up of erratic fragments derived from the Lake District; and when the frequent occurrence of shells of recent species in the Lancashire Middle Gravels is considered, it is not at all remarkable that a few isolated marine shells should be found in these fluviatile Valley Gravels, as the *Cardium edule*, discovered by Mr. Barr at Stockport.

The river Irwell below Kersall Moor, near the Manchester racecourse, has changed its course, as proved by old plans, during the last two hundred or three hundred years, several acres of Salford now being on the Kersall side, and about the same area of Kersall on the Salford side of the river ; for, as pointed out by Mr. Binney, there can be no doubt that the river was once the boundary of the two townships. Under the lowest terrace, or rather at the bottom of the alluvial flat below the terraces, peaty beds and trunks of large oak trees occur in several sections, resting on about six feet of river gravel.

Professor Hull, F.R.S., in 1863 described the great terrace about 40 feet above the alluvium of the Mersey, which rests on Boulder Clay, and is seen in the pits of Cheadle, Didsbury, Bromyhurst, and Barton Grange, where it underlies the thick peat of Barton Moss. From Didsbury the Gravel may be traced through Withington, Hulme, Old Trafford, Patricroft, and through the great plain lying between the banks of the Irwell and Mersey, and extending into Cheshire as far as Timperley and Altrincham. Neither in the terrace, or in that of Lower Broughton, six feet above the present alluvial flat, which is still liable to floods, could Professor Hull find any organic remains.

At Grundy Hill, east of Didsbury, 50 feet above the Mersey, Professor Hull discovered the following section :—

	Feet.
1. Fine laminated White Sand . . .	2
2. Layer of peaty matter, with birch or hazel .	¼
3. Dark laminated Clay	6
4. BOULDER CLAY.	

The laminated clay No. 3 was believed to be "warp," formed when the river had a broader spread across the valley, and deposited the high terraces.

Between Worsley on the north and Altrincham on the south, the breadth of the terrace is seven miles, and the present river valley 50 to 60 feet beneath the highest part of it.

From the investigation of the South Lancashire Valley Gravels it would appear that (1) the Upper Mersey and its tributaries were mainly pre-Glacial; that (2) during the Glacial Epoch they became filled up with Boulder Clay and interbedded sands; that (3) since the period of extreme cold and the re-elevation of the land, they have been re-excavated by the existing rivers, which have left marks of their former higher levels in the terraces, lying on successive heights on the sides of the valleys, the higher and older terrace, in some cases, being as much as 100 feet above the present level of the streams; and that (4) immediately before the deposition of the alluvium of the present alluvial plain, but after most of the valleys had been cut down as low as they are at present, a period of obstruction of drainage took place, and peaty beds were formed in the bottom of the valleys at the same time that the great "mosses" of West Lancashire came into existence.

Comparing the sequence of deposits of the whole of the valleys and plains of West Lancashire, the major part of all the valleys appear to have been excavated between the era of elevation of the surface of the Boulder Clay into land and the time when the maximum of that elevation was reached, when the Isle of Man formed a link in a chain of continuous plains, stretching between the north-west of England and Ireland, which plains afterwards became peat-covered, and by a succession of small subsidences perhaps not yet completed, were let down beneath the Irish Sea.

Investigation of the valley deposits of Central England point to the large amount of denudation which has gone on since the close of the Glacial Epoch, and prove the post-Glacial age of the terraces hanging on the sides of those valleys, as those of the Trent at Burton, described by Mr. Molyneux, F.G.S., and in many valleys further south.

VALLEY OF THE AVON.—Mr. T. G. B. Lloyd, C.E., F.G.S.,* describing the valley of the Avon, mentions terraces of freshwater deposits, consisting of quartzose flinty gravel and sand, containing land and freshwater shells and mammalian remains, obtaining their maximum superficial development between Evesham and Tewkesbury, having a width of about a mile and a-half, and rising about three feet in height above the ordinary alluvial plain. In the Gravel Pit near Little Comberton occurred the fine tusk of *Hippopotamus major*, now in the Worcester Museum. The lower part of the section was found by the Rev.

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* Quart. Journ. Geol. Soc., Vol. xxvi., p. 202.

W. Parker to consist of freshwater shelly clays, and in the gravels above were erratic fragments derived from the Boulder Beds; so that it is clear that the whole series are of freshwater origin, and of post-Glacial date, though in some cases they are as high as 40 feet above the river. Mr. Lloyd describes these terrace beds as being absent in the valley of the Severn between Shrewsbury and Tewkesbury, the marine shells and bones of *Rhinoceros tichorhinus* and *Elephas primigenius* that have been recorded having been derived from the Boulder Clay and other Glacial deposits.

Having described the probable age of the valley deposits of a large tract on the west side of England, where their relation to the Glacial Epoch is observed, and the occurrences of neolithic implements, relegated to the beginning of the formation of the lowest alluvial plain of all, it may be well to notice those sections in the east of England where palæolithic implements occur in valley deposits, the relation of which to the underlying Boulder Clay and other glacio-marine deposits is clear.

At Hoxne, near Diss in Norfolk, Professor Prestwich has described the occurrence of high level gravels with flint implements, resting on sand and gravel with implements, the bones of Mammalia, and fresh-water shells, lying on peat and clay, the whole series occupying a hollow or filled lake or water-course in the Boulder Clay.

At Bedford, in the ancient high-level gravel, lying in a valley which has been cut through a thick bed of Boulder Clay and into the Oolitic strata entirely since the Glacial Epoch, occurred numerous flint implements of the French or St. Acheul type, described by Messrs. Prestwich, Wyatt, and Evans. Here since the Boulder Clay extended across the valley from side to side, the rain has cut down this valley two miles in width, and to a great depth, so that the valley is as clearly post-Glacial as those in the north, where no palæolithic implements have, as yet, been found.

In the Lake District of Cumberland and Westmoreland traces of high-level river terraces are generally absent, or, if present modified by late *glacier action*, and I think from the large size of many of the blocks in terrace gravels of Lancashire, they are probably ice-borne, and that the climate of the north-west of England, during the first re-excavating of the valleys, was too cold to be inhabited by man, which accounts for the absence of implements of old type in the terrace gravels there. Which fact, if true, forms an important link in the chain of phenomena by which I have endeavoured to correlate the sequence of conditions obtaining in the north-west of England, with those which occurred in the south.

VALLEY OF THE THAMES.—Professor Ramsay has well shown how the great elevation of new mountains on the flanks of the *older* Alps, at the close of the Miocene period, gave the Secondary strata, lying until then in horizontal continuity over what is now England and France, their existing low tilt or dip to the north-west. Which tilt gave the initial north-westerly direction to the existing rivers of northern France, the Loire, the Seine, the Marne, and the Oise; and by causing the Chalk of England to form a gentle slope towards the hilly country of Wales and Herefordshire, forced the Severn to run in a southerly direction, and established the first beginning of the great Chalk escarpment that has since been cut so far back by subærial causes. But, before it was cut back any great distance, further disturbances of the strata took place to the east of it, giving the Chalk and overlying Eocene strata a decided tilt to the eastward, which caused the drainage of the Chalk area to flow away eastward. The Thames then came into existence, and commenced to cut for itself a valley through the Chalk, the escarpment of which continued to gradually recede eastward, and from overhanging the valley of the Severn (which, as the Oolitic escarpment also retreated eastward) gradually widened, gaining in extent at the expense of the Thames, which gradually contracted its drainage area.

The gradual eastward retreat of the Chalk escarpment at length bared the edges of the Oolitic strata, which had already obtained their south-easterly dip before the deposition of the Cretaceous strata, which, being of unequal hardness, formed another line of escarpments which also commenced retreating eastwards, but at a far slower rate than the more readily soluble Chalk, the distance between the Oolitic escarpment of the Cotteswolds, and the Chalk escarpment to the east of them, having gradually increased from that day to this, and the process being still in existence, so that the time must come when the Oolitic escarpment forming the present Cotteswolds will have retreated so far eastward that the larger portion of what is now the valley of the Thames, will, through the travelling of the water-shed towards the sea, become a part of the valley of the Severn.

The Chalk, resting on the Oolites with a south-easterly dip, was at length cut down by the retreat of the escarpment to a point relatively lower than the newly-formed Oolitic escarpments to the west of it, which allowed all the water falling on the surface of the Oolites between their escarpment to the west, and the Chalk escarpment to the east, to flow down the dip of the Oolites, and into the Thames valley excavated in the Chalk, which was gradually deepened as the escarpment increased in height, so that in time it was entirely breached by the river which flowed through it.

The map of the Geological Survey, with London in the centre, includes the principal portion of the Valley of the Thames, and I have taken it, and the Superficial Deposit edition of Sheet 7, and the "Ordnance Contour Map" published by the Royal Rivers Commission, as the basis of the following observations

The chief source of the Thames is about 600 feet above the sea; from it to the 300 feet contour the stream descends a horizontal distance of nine miles, and 11 miles more to the 200 feet contour near Lechlade, from which place to the point where the river flows through the Chalk escarpment at Wallingford, near Stoke, is a distance of 42 miles, while to the 100 feet contour is an additional 30 miles, which is reached near Great Marlow, from which the Thames descends 75 feet, at London Bridge 48 miles further on.

The top of the Chalk escarpment, near the Thames, is about 100 feet lower than its source, so that supposing the valley of the Thames not to have been excavated, and the river to flow along the plain, at the top, the stream would have a fall of 100 feet in 62 miles—a fall very similar to that now obtaining between the 200 and 100 feet contours, which are 72 miles apart.

Capping many of the flat-topped hills lying between the valley of the Lea and the escarpment of the London Clay and Plastic Clay, overlooking the Chalk, about Rickmansworth, Watford, and St. Albans, are the Pebble Gravels of probably pre-Glacial age. It will be noticed that with two slight exceptions of patches of gravel on the Plastic Clay, that these Pebble Gravels do not occur in the country lying immediately north of the escarpment. The Chalk is overlaid by an extensive sheet of Middle Glacial Sands and Gravels, through which narrow valleys have been cut exposing the Chalk beneath. Here and there small outliers of Plastic Clay occur, remnants marking the former position of the escarpment further out in the Chalk plain, but what is very important is the fact that on the top of one of these outliers is a patch of the old Pebble Gravel; this small tract is about a mile south of Amersham, and quite seven miles from the Plastic Clay escarpment.

From these facts it is difficult to resist the conclusion that the Pebble Gravels were deposited on an old plain of Lower Tertiary beds, the northward portion of which has been destroyed by the wearing back of the escarpment to its present position.

Eastward of the valley of the Lea, the Pebble Gravels cap the heights of Epping Forest, and underlie the Boulder Clay east of Epping Station. South of Brentford, as at Hampstead Hill, these gravels rest on the Lower Bagshot Beds.

In the valley of the Thames and Lea, that is to say on the slopes lying above the alluvial plains, the gravels do not occur, but on the south side of the valley, two outliers remain at Shooters Hill and Telegraph Hill, Swancombe Park, to testify to the height and lines of the old pre-Glacial valley of the Thames. Whether the old gravels capping the low hills about Oatlands Park, and Virginia Water, belong to this age is somewhat doubtful, but they appear to have been deposited during the same set of conditions.

The Middle Sands and Gravels spoken of as occupying the Chalk area, north of the Watford Escarpment, lie at the foot of it, move transgressively over it, and are found far away on the London Clay to the east, and are consequently of newer age than that of the escarpment. On the other hand not only do none of the Middle Sands, or the Boulder Clay occur on the south side of the Thames, but no traces occur on the valley slopes on the north side. The most southern tract of the large mass of Boulder Clay between Brentwood and Epping is that at Havering-atte-Power, which is about a mile and a half north of the termination of the Thames Gravel of Romford, the level of the latter gravel being about 60ft., and of the Boulder Clay more than 300ft. A most interesting relation of the Glacial Deposits is well shown on the Survey map, where the Middle Sands, covering a large area, at Black Park and Stoke Common, west of Uxbridge, extend to within a quarter of a mile of the Thames Gravel of Stoke Pogis and Farnham Royal, and within five miles of the Thames at Windsor, and separated from the gravels by the scarp of London Clay, which is shown in the Horizontal Section of the Geological Survey, Sheet 74.

From the abrupt manner in which the southern extension of the

Glacial deposits is cut off, there can be little doubt that the older slope, on which they rest, has been denuded away since the time of their deposition, or in other words that the valley of the Lower Thames, with its various sheets of terrace and alluvial gravels is newer than these Glacial deposits. From the fact of the latter being sparingly represented immediately north of the Thames Valley, their thinning out southwards, and their entire absence south of the valley, one must conclude their southern limit on the pre-Glacial plain would nearly correspond to the course of the existing river Thames.

It has already been shown that the river to flow over the Chalk escarpment from the lowest of its several sources, would only have a very slightly greater angle of fall than it has between the 200 and 100 feet contours, lying respectively on the landward and seaward side of the Chalk escarpment; but it is evident from the levels of the top of the Thames Gravels between Windsor and Stoke Pogis, where the valley is only four miles wide, that a considerable portion of the gorge through the escarpment has been excavated since these gravels first commenced to be deposited, and since the denudation of the southern edges of the Middle Drift. When the former channel of the Thames, where it flowed through the Chalk escarpment, was only as high above its present level, as the Stoke Pogis, and Acton gravels are above its present level, the river must have had 100 feet fall more than at present between the Chalk escarpment and the sea.

The Thames Gravel Professor Prestwich described in 1857* as consisting of angular flints, and other pebbles exhibiting a want of roundness, indicating an absence of marine action, associated pebbles of quartz, and various semi-crystalline rocks, rolled into pebbles during the New Red Sandstone period, and derived from the Drift, as pointed out by Dr. Buckland,† who traced the fragments in the Warwickshire Drifts, to their parent source in the Bunter conglomerates of Cannock Chase. The presence of these pebbles in the Dartford gravels was noted as long ago as 1853 by Mr. Trimmer,‡ who pointed out the terrace arrangement of the ground at a height of 150 feet above the tidal level.

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* ' Ground beneath us.'' London, 1857. Quart. Journ. Geol. Soc., Vol. vi., p. 201. Vol. xi. p. 107 Vol. xii., p. 131.

† Quart. Journ. Geol. Soc., Vol. i, p. 310.

‡ "On the Origin of the Soils which cover the Chalk of Kent." Part. 3. Quart. Journ Geol. Soc., Vol. ix., 1853.

In 1860, Professor Prestwich pointed out that these terrace gravels "are the results of river action at a period before the excavation (? deepening) of the present river valleys," and attributed the transport of large blocks to river-ice, and to the fact that the rivers were larger and more rapid than at present, as proved by the coarseness of the gravels and the absence of sand ; flint implements appear to be most common where re-action is stronger.

In the low-level gravels, implements are absent, and Professor Prestwich attributes this partly to those found in the high-level gravels being used as ice chisels, while the low-level beds were deposited when warmer conditions prevailed in the period immediately following the high-level or terrace gravels. That these various gravels were deposited by the existing river, there is ample evidence to show, and that the higher terraces were deposited when the river Thames had not cut down its valley as low as at present, and of more ancient date than the sheet of gravel occupying the lowest plain. But exactly what the conditions were, when the deposition of high-level gravels ceased, appears to be doubtful ; in the neighbourhood of London there is a decided step, or belt of London Clay between the two sets of gravels, first indicated by Mr R. W. Mylne, F.R.S.,* and since proved in the neighbourhood of the New Law Courts, by Messrs. Hudlestone and Price, in a paper in the "Proceedings" of this Association. This bare strip of London Clay, expresses a change in deposition during which the climate ameliorated. This break is not apparent higher up the valley, as in the Maidenhead district, where the low-level and terrace gravels are described by Mr. Whitaker as similar in character, containing occasionally, as pointed out by Professor Prestwich, pebbles from the New Red conglomerates, and more rarely fragments from the Oolites. East of Maidenhead, the gravels have a width of four miles, while to the west, in the Chalk country, they are restricted to a breadth of from three-quarters of a mile to two miles. Between Marlow and Henley, the gravel is mainly made up from the *débris* of the Chalk itself ; at Hurley, at a depth of eighteen feet, occurred a large number of mammalian remains, including the hippopotamus and the cave tiger. Similar mammalian deposits occur at Brentford, on the seaward side of London, associated, as long since pointed out by Professor Morris, with fluviatile shells, which he believes lived near the spot. The mammalian fauna of the gravels near Kew Bridge, described by

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* "Geological Map of London," Stanford, London, 1851.

Trimmer and Morris, belong to the mid-terrace. In the higher terraces of the neighbourhood of Acton and the Thames, lying beneath the 100 feet contour, Colonel Fox has obtained a large number of flint implements, associated with a tree believed to be *Pinus sylvestris* by Mr. Carruthers, and *Elephas primigenius* identified by Professor Busk, the only tooth of that species found in the high-terrace, the fauna obtained from the mid-terrace by Professor Morris occurring beneath the strip of London Clay before alluded to. The flint implements occurred in the mid-terrace of Brentford and Turnham Green, Hammersmith, described by Colonel Fox, or at the 40 feet terrace of the New Law Courts, described by Mr. Hudleston; and in fact no flint implement of the Drift type has been recorded from any gravels, below the fifty feet contour, except those that have been found in the bed of the Thames itself.

The Thames Gravel rests unconformably on the Ilford Brick-earth, as is well seen in the Uphall brickfield, where the brick-earth thins out eastward, and is succeeded conformably by bright-yellow freshwater sands, which contained the tusk of *Elephas primigenius*, the Thames Gravel overlying both the deposits. Northwards the gravel increases in thickness to fifteen feet at Ilford Station, half-a-mile east of which the brick-earth—Lower Brick-earth of Mr. S. V. Wood, junr.—again crops to the surface at the London Road field. At Erith it has a thickness of nearly 30 feet.

Mr. Gwyn Jefferys has pointed out the northern character of the shells *Helix ruderata*, and *H. fructicum*, occurring at Ilford, which deposits may correspond to terrace gravels higher up the Thames, containing the remains of the musk ox, first discovered by Sir John Lubbock, and identified by Professor Owen, in gravel which Mr. Whitaker considers to be a terrace gravel above the gravel of the river plain.

The shell-bearing sands occurring at several points between London and the sea, are of far newer date, being apparent local deposits of a period immediately succeeding the gravels of the lowest plain, and preceding the growth of peat.

The deposit of bright yellow, red, and grey sands, with occasional seams of gravel found under Pall Mall and Spring Gardens, probably belong to the same period as the *Cyrena fluminalis* beds of Grays, for they contain a small variety of the latter shell, and a plentiful mammalian fauna. The dwarfed form of the *Cyrena* may possibly be due to the incoming of brackish water, which idea is, to some extent, borne out by the presence of rolled Thanet Sand fossils, in the ferruginous gravels associated with the sands, suggesting a current from the east, but the bed immediately below is full of ordinary freshwater shells, as *Succinea* and *Lymnea*. The base of these sands at Cockspur Street, rests on the London Clay, at a level of probably less than 10 feet below the Ordnance Datum-line.

In Lancashire there is ample evidence that a subsidence took place, after the main valleys had been cut as deep as they are at present, during which post-Glacial marine beds were thrown down, which era was immediately succceeded by a slight elevation, accompanied by obstruction of drainage. In the valley of the Thames, a similar sequence would appear to have occurred. The Pall Mall and Grays beds, corresponding to the Shirdley Hill Sands and Presall Shingle.

Professor Morris describes the Upper series of beds at Grays, consisting of false-bedded unfossiliferous sands and brown clays, as formerly being seen resting, in clear sections, on the Lower or fossiliferous zone, comprising the gravel and overlying brick-earth, in which the remains of *Cyrena*, *Paludina*, &c., occur, and expresses his opinion that "the deposit at Grays may be mainly due to the action of a river flowing through a valley which it has partially excavated, in the Lower Tertiary and Upper Chalk beds, and most probably posterior to the Boulder Clay period." Previously to 1857, the late Sir Charles Lyell, whose loss we can hardly realize, and so deeply deplore, believed these beds to be pre-Glacial, and older than those of Brentford, but he in that year stated his uncertainty as to their age.

Mr. S. V. Wood, jun, in 1866, described the Grays deposits as consisting of 15 feet of blue clay, overlain by 20 feet of false-bedded sand, and believes it to be later than his Upper Brick-earth overlying the Thames Gravel, which was faulted by a dislocation, followed by denudation which destroyed all the southern slope of the Thames Valley east of London, with the exception of a remnant forming Shooters Hill. Mr. Wood pointed out that the greater part of the Grays brick-earth partly overlies the gravel of the lower terrace, which is continuous with that of the valleys of the Darent and the Cray, and which is beneath the higher terrace of the brickfield at Crayford.

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* "Ge logical Magazine," Vol. iv., p. 64.

The gravel of the lowest plain at London, and seawards, is here and there overlaid by alluvium, near the base of which, on the seaward side, is a deposit of peat, which occasionally crops to the surface, as in the Surrey Commercial Docks, which I had lately the opportunity of visiting, where the peat, with trees, rests on the low-level gravel. In the Crossness Outfall boring, $6\frac{1}{4}$ feet of peat occurred beneath 9 of alluvium. At Deptford the peat was 10 feet in thickness, and in a well at Erith, no less than 20. At Greenwich Marsh $8\frac{1}{2}$ feet of peat occurred in the centre of $20\frac{3}{4}$ feet of alluvial clays, resting on sand and gravel.

From this it is evident, that the peat underlying the recent Thames alluvium, is much newer than the most recent of the Thames Gravels which underlie it, in a manner similar to that in which the marine Presall Shingle and old river gravels underlie the peat of Lancashire. Colonel Lane Fox points out that the pre-Roman station at Dorchester Dykes at the junction of the Isis with the Thames, proves that the latter river ran its present course, and under nearly the same conditions during the Bronze-period as at present. At the mouth of the Brent at Kew, and at Barnes on the opposite bank, piles of ancient river habitations occur, associated with a number of flint celts, and dolichocephalic skulls of a form believed to have belonged to the earliest inhabitants of these islands, and Colonel Lane Fox comments on the enormous periods of time, since the river excavated its valley—four miles and a half in width—from the 100 feet contour down to its present level, which has practically been unchanged for the last two thousand years..

From an examination of the sections that have been exposed during the last seven years, in making the double line of the London and North Western Railway, between Hertfordshire and Lancashire, I have been led to believe that the sands and overlying Boulder Clays are of the same age in the one county as in the other; but, whether this be so or not, it is certain that these deposits represent *the close of the Glacial* submergence, and that this submergence of the land lessened in extent southwards, so that the whole of the country, south of the Thames, was a long island, as suggested by Mr. Godwin Austin. The Glacial deposits probably extended further south than we now find them, having been removed by that fluviatile denudation which has excavated the lower valley of the Thames since the era of the Boulder Clay. Professor Prestwich has shown that there is good reason to believe that the elevation of the dome of the Weald commenced during the Thanet Sand period, so that the escarpment of the North and South Downs may well have begun to be formed at the commencement of the Tertiary epoch.

Looking at all the observed facts, it appears (1) that the whole of the lower portion of the Thames Valley was excavated since the deposition of the Upper Drift or Boulder Clay; that (2) as the valley was gradually cut down, gravels were deposited, and in still later times gravels and brick-earths. One of the earliest brick-earths that has been preserved from denudation, being the Lower Brick-earth (x 4' of Mr. Searles Wood, Jun.) of Ilford. The gravel overlying, Mr. Wood believes to have been formed by the sea, but from its character, its gradual descending slope and other reasons, I think it is more probably fluviatile, formed when the Thames was a tributary to the Rhine, and the united rivers flowed over the plains of the German Ocean. After which an era of obstruction of drainage occurred, trees grew at the bottom of the valley, and were followed by a growth of peat. Before comparing these sequences with that described in the North of England, it may be well to see what light is thrown on the relation of the two by an examination of the valley deposits of the South of England.

Valley of the Medway.—Messrs. Topley and Forster, in their paper "On the Superficial Deposits of the Valley of the Medway," describe river gravels as occurring at all heights in the valley of that river, from the present alluvial plain to 300 feet above it, and it is impossible to draw a line between the higher and the lower gravels, and the former, like the latter, consist of pebbles derived from the Wealden Area. Between Allington and Aylesford there is a terrace 20 to 30 feet above the present stream; further down the Medway Valley, near Aylesford, there is a 40 feet terrace, in which occurs the well-known Mammalia-bearing gravel-pit near the church. At the top of a hill near Maidstone Gaol occurs a terrace at 200 feet, and half-a mile east of East Malling Heath gravel occurs at 300 feet above the Medway. Mr. Topley comments on the fall of these terraces down the valley being more rapid than that of the present stream, and remarks that Professor Prestwich had observed the same fact in the valley of the Waveney (Phil. Trans., 1864, p. 252), and Mr. Bristow in the terraces of the Thames Valley. Messrs. Topley and Forster point out that as the gravels are found at all levels up to 300 feet, the river has deepened its bed gradually, and that no agents but rain and rivers have been at work in the Medway basin since the river ran at the 300 feet level, and show how large an area has been denuded in that basin since that period. And they state their belief that the Wealden Area was never under water during the Glacial Epoch.

South-east Coast.—At the top of the West Cliff at Folkestone, at an elevation of 114 feet above the sea, occurs the deposit known as the Battery or Elephant-bed, the eastern extension of which is cut off by the valley terminating at the Harbour, at the bottom of which alluvial beds rest on a peaty seam. To the west the Battery deposit thins out near the church against a much more recent brick-earth, which caps the Lower Greensand. In 1866 I took the following section near the Battery, partly from information received from Captain Sweeney, R.A.:—

	Ft.	in.
1. Vegetable Mould	3	3
2. Kentish Rag flagstones of old Monastery	0	3
3. Clay with oysters, bones of ox (Mediæval remains)	2	6
4. Small Shingle	6	4
5. White Loam, with *Helix concinna*, *Sus oblonga*, *Terebratula*, &c., from the Chalk; and *Ammonites interruptus* and fossils from base of Gault . . .	6	4
6. Large angular flints, with bones of Mammalia, and fragments of Gault Junction-bed	1	6
Folkestone Bed, to sea level . .	95	0

At the back of the ground occupied by the Battery is the Bayle Pond, supplied by a spring in the calcareous bed No. 5, of which there is a monkish legend, that the Lady Abbess by incessant prayer brought the water up the hill. From the Bayle towards the Town Hall the ground slopes away, and the Battery deposit thins out, and is overlaid by the later brick-earth, but I discovered another fragment of the deposit in an excavation for some cottages behind the Viaduct, the section being as follows :—

	Ft.	in.
1. Clay with few angular flints . . .	4	0
2. Band of Dark Clay (Brick-earth like No. 1)	1	0
3. Clay, partially sandy and partly calcareous (equals Bed 5 of Battery bed) .	6	0
4. Flinty Gravels, with Chalk fossils, nodules of oxide of iron from the Grey Chalk (equals Bed 6 of Battery) . . .	2	9
5. Folkestone Beds (visible) . . .	4	0

There can be little doubt that the Battery and Viaduct sections are the sole remaining fragments of an old fluviatile alluvial deposit, which was formed before the present valley, separating the east from the west cliff, at a time when the sea-cliffs stood far out in what is now the English Channel, and at a time when the Chalk escarpment forming the North Downs had probably not retreated quite so far north as at present. The escarpment was evidently breached by streams flowing off the downs to the north into what may be called the Battery River, as Upper Chalk Foraminifera have been recognised by Professor Rupert Jones in the calcareous seam No. 5,[*] and the large Chalk flints in the lowest bed would also point to an Upper Chalk origin ; their partial angularity would rather suggest their having been transported by the agency of river ice.

In the more recent brick-earth spread over the Greensand and Gault plain occur remains of *Bos primigenius*, *B. urus*, and *Sus*, *Helix concinna*, *Succinea oblonga*, and other land and freshwater shells.

In 1863, the late Dr. Falconer, V.P.R.S., wrote some notes[†] on the bones discovered in digging the foundation of the Battery at Folkestone, now in the Museum of the Geological Society, and mentioned a section of the beds made by Lieut. R. Vetch, R.E., consisting of made earth 6in. deep, whitish loam, used as brick-earth, 4ft. 6in. to 7ft. 6in., marl and flint gravel, with fossil bones, 18in. thick. The latter Dr. Falconer described as unrolled and as all being of the same mineral condition, and as belonging to the following species :—*Hippopotamus major* (*humerus*, anchylosed *right radius* and *ulna*, *right scapula*, *axis*, and three *cervical vertebræ*). *Cervus megacerus*, *Rhinoceros* probably *R. leptorhinus*, *Elephas*, sp. doubtful (*E. primigenius*, and *E. antiquus* occur at Folkestone). *Bison priscus*, *Cervus tarandus*, *Bos priscus*, *Sus* (rolled lower jaw). To this list Professor Boyd Dawkins adds the following species :—*Cervus elaphus*, *Rhinoceros tichorhinus ;* and in Mr. Mackie's list is also *Hyæna spelæa.*

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[*] Mackie "On Folkestone Elephant Bed" (Quart. Journ. Geol. Soc., Vol. vii., 1851).

[†] "Palæontological Memoirs, and Notes of the late Hugh Falconer, A.M., M.D," Edited by C. Murchison, M D., F.R.S., p. 564.

SOUTH COAST.—Professor Prestwich, in 1864, expressed his opinion that the break between France and England was not the result of the last geological change, but that the Channel had existed certainly during the period of the formation of the low-level gravels, and possibly during that of the high-level, of the Thames and Somme valleys.

In the Sangatte* raised beach he found in 1865 two pebbles of red granite, probably from Cotentin, and various fragments of the Oolitic series of the Boulonnais, which he considers affords additional support to his view of an open channel to the westward. Above the beach are 20 to 80 feet of loam, chalk, and flint rubble, with land shells (Loess).†

An examination of the Admiralty Charts of the English Channel shows that there is no part of the English Channel, near either of the lines of the proposed tunnel, deeper than 30 fathoms, which is 5½ fathoms less than I found Lake Windermere, in Westmoreland, to be on sounding it last year. The great probability that the anticlinal axis of the Weald formerly extended across the Channel to France, and marked the old water-shed, renders it almost certain that streams flowing north, towards the prolongation of the Thames, would probably have not cut their valleys very deep, and that the chance of filled up fissures being met with is exceedingly small.

The Brighton raised beach has been so often described since the days of Martin, Mantell, and Murchison that it is almost needless to recall its characteristics. In 1859 Professor Prestwich traced it past Arundel to Chichester and Bourne Common, and showed that though at Brighton it was only 8 to 12 feet above the present level of the sea, at Arundel it was 100 feet, and at Bourne Common, 42 miles distant, it was 140 feet. Ten miles west of this point Professor Prestwich showed, in 1871, that at the top of Portsdown Hill, at an elevation of 125 feet, and 85 feet above the angular ochreous gravel of Chichester, Havant, and Portsmouth, there is a true shore deposit, 4 to 6 feet in thickness; in the earthy bed above it occurred a rough flint implement.

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* 'Additional Observations on the Raised Beach of Sangatte." Quart. Journ. Geol. Soc., 1865.

† " On the Loess and Quarternary Beds of the North of France and South East of England." Phil. Trans., 1864, part ii.

In the valley of the Avon in Hampshire, Professor Prestwich describes several terraces of gravel, respectively 30 to 70 feet, 150 to 180 feet, and 200 to 250 feet above the river; in the highest, he found some flint implements, near Downton, Fordingbridge (320 feet above the sea). The flint implements of Salisbury, described by Mr. Evans, F.R.S., occurred at 110 feet above the present river; those of Southampton 86 to 150 feet above the river.

The high level plains of the mainland of Hampshire, described by Mr. Codrington, F.G.S., can be traced inland northward to a gravel-capped escarpment 20 miles inland, 420 feet above the sea, and 200 feet above the ground to the north. These plains are all capped with gravels and brick-earths, deposited by rivers when the land stood further out to sea than at present; the continuity of the old valley slopes being broken by the existing narrow valleys, and by the sea-cliffs, capped with the gravel, from 100 to 120 feet above the sea, as between Poole and Bournemouth, in which the flint implements have been discovered at various times. At Barton and Hordwell cliffs the thickness of the gravel is 18 to 20 feet; in 1757 it was described as 18 to 20 yards; and in 1821 as 56 feet, which as the coast wastes a yard a year must have been the thickness of the cliffs considerably in advance of the existing ones, the gravel rapidly thinning inland.*

No organic remains have been recorded from the gravel of the plains, though they occur plentifully in the valley gravels intersecting them, but two flint implements† have been found in the gravel-pits of Southampton Common, at 86 and 150 feet above the sea. The flint weapons in all cases appear to have been derived from the white gravel which overlies the red, and the brick-earth.

Sarsen-stones occur everywhere, and in large size in the gravel between Gosport and Southampton Water, 170 feet above the sea.

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* Quart. Journ. Geol. Soc., 1870.

† Quart. Journ. Geol. Soc., Vol. xiii., p 48.

On the 100 feet plain east of Poole Mr. Godwin-Austin records waterworn pebbles of white quartz, granite, and porphyry ; and Mr. Codrington describes white quartz as far east as Lymington, and granite, syenite, and greenstone in the low gravels 27 feet thick of Southsea, which are probably connected with the Brighton raised beach. Similar gravels cap the flat-topped hills of the Isle of Wight, from 100 to 300 feet above the sea, and at Headon Hill at 390 feet, the sole remaining portion of an old table-land sloping northwards towards the main land. No organic remains occur, though they are plentiful in the terrace gravels, high up the sides of the present valleys.

The immense antiquity of palæolithic man as stated by Sir Charles Lyell, is nowhere better shown than in Hampshire, from the clearness of the evidence of the changes that have taken place in the contour of the valleys and the outlines of the sea coast, and from the excessive denudation of Cretaceous and Tertiary strata since man's advent.

Professor Prestwich, in his paper on " The Quarternary Phenomena in the Isle of Portland and around Weymouth" (Quart. Journ. Geol. Soc., 1875), after giving an elaborate description of the various Drift deposits of the districts, including the Portland Mammaliferous Drift, which occurs about 400 feet above the sea, and contains large blocks of sarsen-stones, *Elephas antiquus*, &c., states his opinion, that, about the close of the Glacial Epoch, before the present valley systems were elaborated, " a broad tract of Chalk, bounded in places by Greensand, and capped by Tertiary beds and older gravels rose inland ;" . . which " were brought into level juxtaposition by and along the great line of fault running westward and eastward nearly midway between Dorchester and Weymouth." From this area the ground sloped southward to the termination of the Isle of Wight, the plain of Weymouth not having as yet been excavated, and that rivers ran over this surface, one of which carried the detritus, and mammalian remains found in the Mammaliferous Drift.

The coast line from Cornwall to the south end of Portland had probably fewer deep bays, and ran straight from headland to headland; eastward it trended inland by Fareham and Chichester, and cut the present sea coast at Brighton. Then, as now, the shingle drifted from west to east, while floating ice may have transported the larger masses on the Sussex coast from more distant localities.

In the meantime Professor Prestwich* believes "an east and west anticlinal disturbance elevated the Weymouth district, and with it part of the Purbeck and Portland area succeeded or accompanied by a denudation which not only levelled but deeply channelled the uplifted areas." After which various angular land *débris* and loam, Greensand drift, high-level and low-level gravels, were deposited.

The Mammaliferous Drift Professor Prestwich correlates with the Portland raised-beach which is 24 feet above the present beach at the Bill, rising to 53 feet at its north-eastern extremity. Of the 28 shells occurring in it all but one, according to Mr Gwyn Jeffreys, are now living in the British Channel, but all have a more northern range, and *Cyamium minutum*, a small Greenland shell, occurs in thousands.

The loam, head, or talus, lying at the top of the old beach, is evidently sub-aerial, and, as Mr. Godwin-Austin says, describing these beds at various points in the English Channel, Channel Islands, and the coast of Cotentin, "the materials are always local in origin," while he believes them to have been formed when, through elevations of great amount, the higher tracts of "the country were regions of excessive cold," the low areas were subjected to great cold though not perhaps of a glacial nature.

SOUTH WEST COAST.—Mr. Godwin-Austin, as far back as 1837, showed that there were river terraces in Devonshire. Two years later Sir Henry De la Beche, described the raised beaches occurring round the coasts of Cornwall and Devon, some of which had been noticed by Borlase in 1758, their height above the sea, varying from 12 to 50 feet, formed probably during the same period as the marine silt found in the valleys of the Otter and Exe, first noticed by Mr. Godwin-Austin.

Sir Henry De la Beche appears to have considered the raised beaches to have been formed after the submarine forest period, but it is more probable, correlating the submarine peat beds occurring at Tor Bay, Mounts Bay, &c., and in the Bristol Channel, with those of Lancashire, that the raised beaches are of older date, and belong to that set of conditions which threw down the Presall Shingle in Lancashire, and the Brighton raised-beach; and indeed

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* "On the Superficial Accumulations of the Coast of the English Channel, and the changes they indicate," Quart. Journ. Geol. Soc., Vol. vii., p. 118 1851.

Sir Henry describes the great peat deposits of the Bridgewater Levels as resting on old sand, mud, and shingle, which rise up through the peat as pointed out by Conybeare and Dr. Buckland, and which are now known as the Burtle Beds.*

It may be well to notice that marked peculiarity of some of the Cornish alluvial deposits, the occurrence of stream-tin, which invariably lies at the bottom of the alluvium, and is even often forced down into chinks and crevices of the rocky floor, locally called the *shelf.* It is easy to understand how readily, as pointed out by De la Beche, veins of oxide of tin occurring in decomposed granite would get broken up, rolled into pebbles, and deposited in the alluvium by the streams, in which by their superior weight more than twice that of granite, the pebbles would soon come to rest and go to the bottom.

De la Beche gives the following section of the stream-tin works of Pentuan, observed by Mr. Colenso :—

	Ft.	in.
1. Rough River Sand, and Silt, mixed with Sea Sand, at the bottom of the deposits, stakes for a foot bridge occurred at the level of low-water	20	0
2. Sand, Timber Trees, bones of Red Deer and Whale, and Human skulls . .	20	0
3. Silt or Clay, 2 feet. Sand with sea shells 4in.	2	4
4 Silt, lead-coloured in places, shells, horns, bones	10	0
5. Dark Silt, Moss, Leaves of Trees, &c., 48 below high-water mark	1	0
6. Tin Ground. Roots of Oak and other trees, at the top, some with oysters attached to them	3 to 10	

In several other sections given, charred wood, human skulls, and wood cut with an axe occur in the bed immediately overlying the tinstone bed, which, compared with the alluvial deposits of Lancashire, appears to occupy the horizon of the large river gravel at the base of the ordinary alluvium of the lowest plain, which is probably nearly synchronous with the West Lancashire post-Glacial marine beds.

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* "Report on the Geology of Cornwall, Devon, and West Somerset." London, 1839, p. 416.

On the Cornish Coast there would appear to have been a deposit of marine silt after the growth of the peat, on the tin-stuff, in the estuaries, and of peat and alluvium in the valleys, corresponding with the *Scrobicularia*-clays resting on the peat in the West Lancashire plains, and the fluviatile alluvium in the valleys. Mr. Belt has pointed out the remarkable fact that all the areas in the world in which stream-tin and alluvial gold occur, are regions which have never been glaciated. Glaciation, he considers to have swept away any traces of these metals in various countries where they once must have existed, and it is important to note the absence of anything like glacial detritus in the Cornish and South Devon tin area; and he points out the striking support given to this view by the presence of the Norman flora at the present time in that area, which no doubt existed there before the Glacial Epoch, and managed to live on, though doubtless numerous species succumbed. Professor E. Forbes speaks of it as being more ancient and more southern in character than the Kentish flora, itself older than the Germanic in Britain.

The French Coast of the Channel.—The Somme valley between Amiens and Abbeville is about a mile across. At the top of the plain, on either side, is the upland loam without shells, and hanging on the higher slopes is the high-level gravel, about 30 feet in thickness; beneath this is a terrace of low-level gravel, with elephants' bones and flint tools, and still lower the alluvial plain, which consists of 20 to 30 feet of peat resting on gravel. It will be at once apparent how close is the resemblance to the sections of the Lancashire rivers, where terraces of gravel fringe the side of the valleys, and peat occupies the lowest horizon but one of the alluvial plain.

The great beds at the mouth of the Somme extend out seawards, and prove that the valley formerly extended out into the British Channel. Near the surface of the peat occur Gallo-Roman remains, and at greater depths neolithic weapons, as is the case in the peat section on the Cheshire coast. In the basement beds of the low-level Somme gravels, *Cyrena fluminalis* occurs, and some marine shells mixed with the freshwater forms.

In the high-level gravels of the Seine, near Paris, Professor

Prestwich found traces of ice-bearing action and contortion of beds, as in the high-level Amiens beds. All the fragments found in the basin of the Seine belong to rocks in that area, but the great size of some of the travelled blocks of granite point to floating river ice. One of these blocks, now in the Ecole des Mines, is stated by Sir Charles Lyell to be nearly 4 feet in diameter. In 1862 M. Lartet discovered in the low-level gravels of Clichy flint implements of the Amiens type, associated with remains of *Elephas antiquus*, and *E. primigenius*.

CONCLUSION.

It has been shown that in the case of the river Ribble a wide and extensive valley has been cut out entirely since the deposition of the Upper Boulder Clay, that terraces fringe the sides, and that peat beds occur near the bottom of the lowest alluvium, which are continuous with extensive peat beds underlying the sea level, and yet resting on post-Glacial marine beds, proving that the land was lower after the Glacial Period and the formation of the terraces than it is at present, and that afterwards it became higher, when neolithic man emigrated from more southern districts over continuous land.

In the Irwell still more extensive denudations had taken place, and wider terraces formed, peat again occurring near the bottom of the alluvial plain.

In the Ouse also occurred high-level gravels, lying in a valley excavated out of the Boulder Clay, and in these are found palæolithic flint weapons.

In the Thames basin Boulder Drifts were shown to be present, reaching down nearly to the valley, which abruptly cuts them off, and in which are deposited various high and low-level gravels, the former with palæolithic remains of human art, there being the strongest reason to believe that the whole of these terraces, like those of the northern valleys, were formed since the deposition of the Glacial deposits, during which period the Weald district remained an island above water, and extended much further out into the English Channel than at present, the Battery River at Folkestone flowing eastward over this old plain.

At a later period the valleys were cut down, modern alluvium formed, with peat and submerged forests at the base, both on the south and west coasts and in Northern France, where a similar sequence from the palæolithic gravels to the peat era obtained;

but, as proved by the French coast-beds with sea-shells, there was an episode of subsidence, as in England, as proved by the Sussex raised-beach, the Burtle-beds of Somersetshire, and the Shirdley Hill Sand of Lancashire; at the same time rivers higher up on the land were depositing the massive gravels, and in Cornwall the tin-stone beds found beneath the peat. After the obstruction of drainage caused by elevation, that produced the peat, gave way, the country subsided a little, and the relative levels of land and sea have remained tolerably constant since the Roman era.

[illegible]